Recent Developments in Scheduling With VieVS

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1 Introduction

Generating a good schedule is critical for each VLBI experiment, because the schedule determines the quality of the parameters which should be derived by the session. Within the IVS, usually a schedule is prepared with a scheduling software, like SKED (Gipson, 2012) or VieVS. With the VieVS scheduling software it is possible to create schedules automatically, semi-manually or manually. It supports different optimization strategies and parameters, like a station based approach optimizing the sky coverage over each station. However, the large amount of different optimization parameters can lead to troubles finding a good set of parameters to use for the scheduling process. Previously it was time consuming to test different parameters with VieVS because each time the parameters had to be changed manually and a new schedule had to be created. Then these schedules had to be selected manually to simulate observations. Afterwards the simulated session files had to be selected manually again to run a least squares adjustment to estimate geodetic parameters. This procedure was highly inefficient and time consuming. With the new changes in the VieVS software all steps can now be done automatically.

2 VieVS multi scheduling tool

The VieVS software is organized in different modules. To analyse a VLBI session the modules VIE_INIT, VIE_MOD and VIE_LSM are necessary. Vie_INIT reads in all files and prepares files in the VieVS internal format. VIE_MOD models the theoretical time delay for each observation and VIE_LSM calculates the target parameters in a least squares adjustment.

Three extensions to the core modules, VIE_GLOB, VIE_SCHED and VIE_SIM are also available. VIE_GLOB is used to run a global VLBI solution, VIE_SCHED is the dedicated scheduling module and VIE_SIM is used to simulate observations including white noise, tropospheric turbulences and clock drifts (Pany et al., 2011).

While VIE_GLOB is well connected with the rest of VieVS, VIE_SCHED and VIE_SIM were kind of standalone features. This is now changed, Figure 1 shows the new interactions between VIE_SCHED and VIE_SIM. It is now possible to create a schedule for a VLBI session, to simulate this session multiple times and perform a least squares adjustment for each simulated session automatically. This is a lot more efficient, because similar calculations only need to be done once and no user interaction is required except for the start when everything is set up. To speed things up even further an improved multicore support is added for the scheduling part, which can be used if the computer has a multicore CPU.

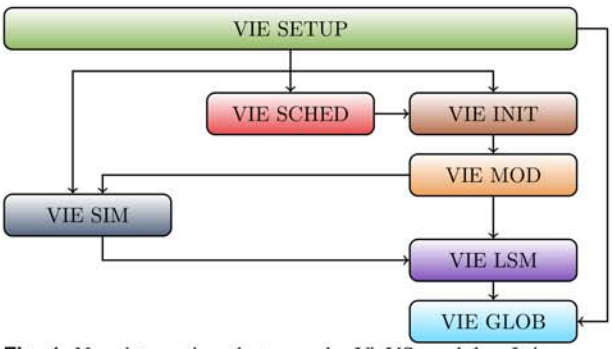

Fig. 1: New interactions between the VieVS modules. It is now possible to schedule, simulate and analyse sessions at once.

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3 Test case 1: impact of a new station in Africa

The first test case investigates the impact of a new station in Africa on an existing network. Therefore a network with seven stations was used and an eighth station was added at different locations in Africa (Fig. 2). Each red dot represents one station in the existing network. Each green dot represents a possible station location for the eighth station. Altogether 99 possible station locations were taken into account. For each location 12 schedules were created with different starting dates. Each session lasts for 24 hours and was simulated 100 times. This ends up with almost 120000 simulated sessions. Figure 3 shows the results. Due to the huge amount of data, it is possible to either look at the repeatability or at the mean formal errors of certain parameters, which agree quite well with each other.

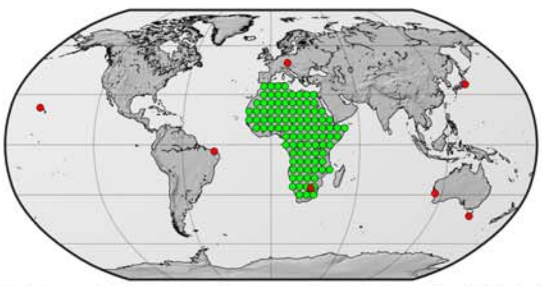

Fig. 2: Investigated network: seven fixed stations (red dots) plus one station with 99 possible positions (green dots)

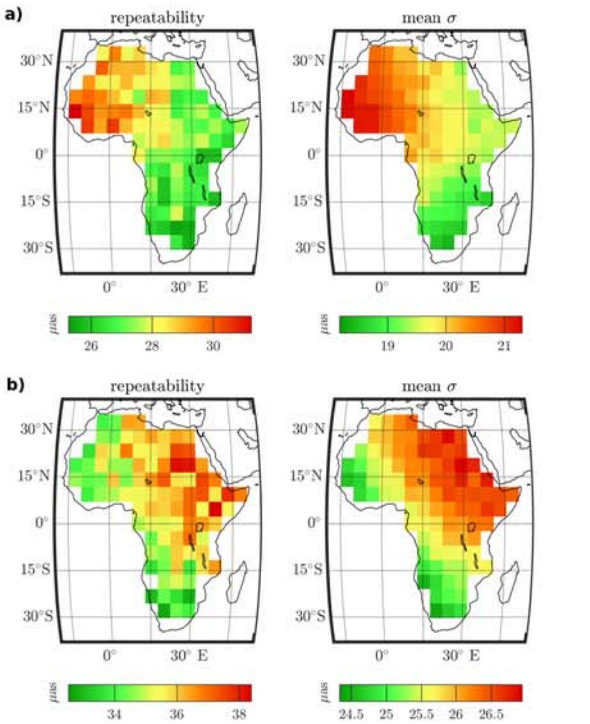

Fig. 3: Results from Monte Carlo simulations. Left column is repeatability over each simulation, right column is mean formal error. **a)** polar motion x-axis, **b)** polar motion y-axis

Figure 3 shows that it is difficult to get one preferred station location where all parameters benefit most. For example, while for improving the polar motion in x direction the south and the east parts of Africa are preferred, for polar motion in y direction the south and the west lead to the best results. It was unexpected that the south is among the best possible locations, because with HART15M there is already a station available in the south. This needs further research. It should also be noted here, that the effect of only one existing network is studied. With different networks the results could change. To find the best possible location of a new antenna in Africa in general, different networks need to be investigated.

4 Test case 2: Choosing appropriate weight factors

Selecting a good set of parameters is not an easy task. However, with the changes in the VieVS software it is now easier to test different parameter setups. To understand what weight factors are best suited it is necessary to understand how the VieVS scheduling tool works (Sun et al., 2014). The schedule is created scan by scan. To select a next scan, all available scans are considered with simple models. Some conditions are applied to reduce the otherwise huge number of possible next scans to speed up the calculation. For the remaining scans, more rigorous models are used to calculate all necessary parameters and to perform internal checks. Each scan is then given several scores. Usually a score for the improvement of the sky coverage, a score for the number of observations and a score for the total time it takes to observe the scan. The weight factors now simply specify how these scores are added together to get a final score. The scan with the highest final score is then used as the next scan and the whole process starts again. This means using good weight factors directly influence the schedule, because via the weight factors the scans are selected. Figure 4 shows all investigated sets of different weight factors. A total of 92 possible sets of parameters were used.

Two different networks were used to search for a good set of parameters, the Austral network and a global network. The main difference between the networks is that the Austral network consists of 5 stations and no subnetting is used to create the schedules. For the global network 8 stations were used with subnetting. For the

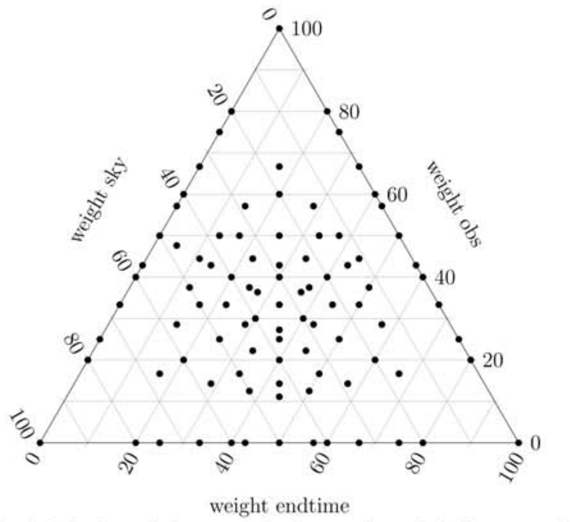

Fig. 4: Relative ratio between the three main weight factors used in VieVS. Ninety-two different sets of parameters (black dots) were used to create schedules.

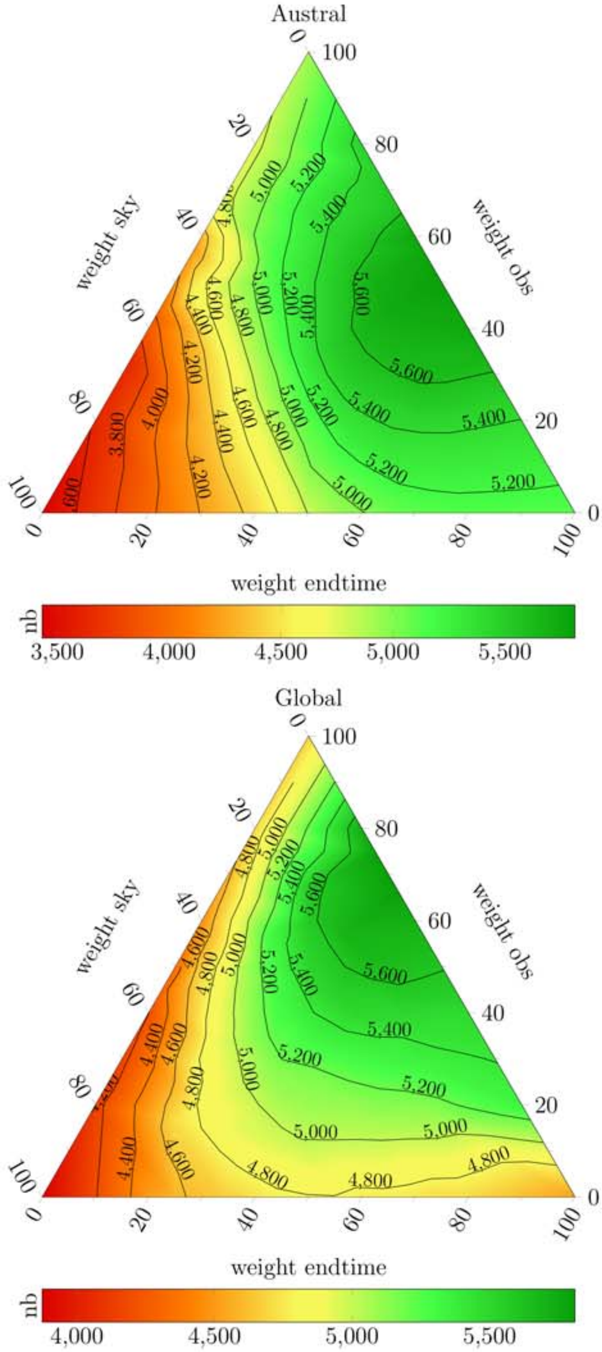

Fig. 5: Mean number of observations investigated at 92 sample points. Space between sample points is interpolated. The maximums for Austral network and global network correspond quite well.

Austral network 6 schedules with different start points were created for each set of parameters and each schedule was simulated 50 times. This adds up to 27600 simulated sessions. For the global network 10 schedules were created and again simulated 50 times which adds up to 46000 simulated sessions, which means in total more than 73600 sessions were simulated. Figure 5 shows the mean number of observations per schedule for each set of parameters. Usually a high number of observations is a good indicator for a good schedule. A clear maximum can be seen, which corresponds quite well between the Austral and the global network. Figure 6 shows the mean estimates of the polar motion along the x-axis. The result is quite different between the Austral and the global network. While for the Austral network, parameters with a high weight for the scan endtime lead to good results, for the global network a more balanced set of parameters leads to better results. The result looks almost identical for other parameters, like polar motion in y-direction or station coordinates. It should also be noted here, that the parameters which lead to the highest number of observations are not the parameters which show the best result. Therefore we recommend to simulate a schedule and look at the expected precision of the estimated geodetic parameters.

Table 1 lists sets of parameters, which lead to the best results when used in VieVS. The large amount of schedules was necessary, to reduce the noise in the results. This means that two sets of parameters, which are close to each other, can give very varying results. Therefore it is recommended to use the multi scheduling tool to create multiple schedules with similar parameters and to simulate the schedules to pick the best one.

5 Conclusion

With the new changes in VieVS it is possible to create large scale Monte Carlo simulations automatically which can be used for several research. It is shown, that it is difficult to select a good station location for a new antenna. Looking at different parameters like polar motion or station coordinates would lead to different pre-

Table 1: List of parameters which should be used to create a schedule.

Network	weight endtime	weight nobs	weight sky
Austral	0.6	0.2	0.2
global	0.4	0.4	0.2

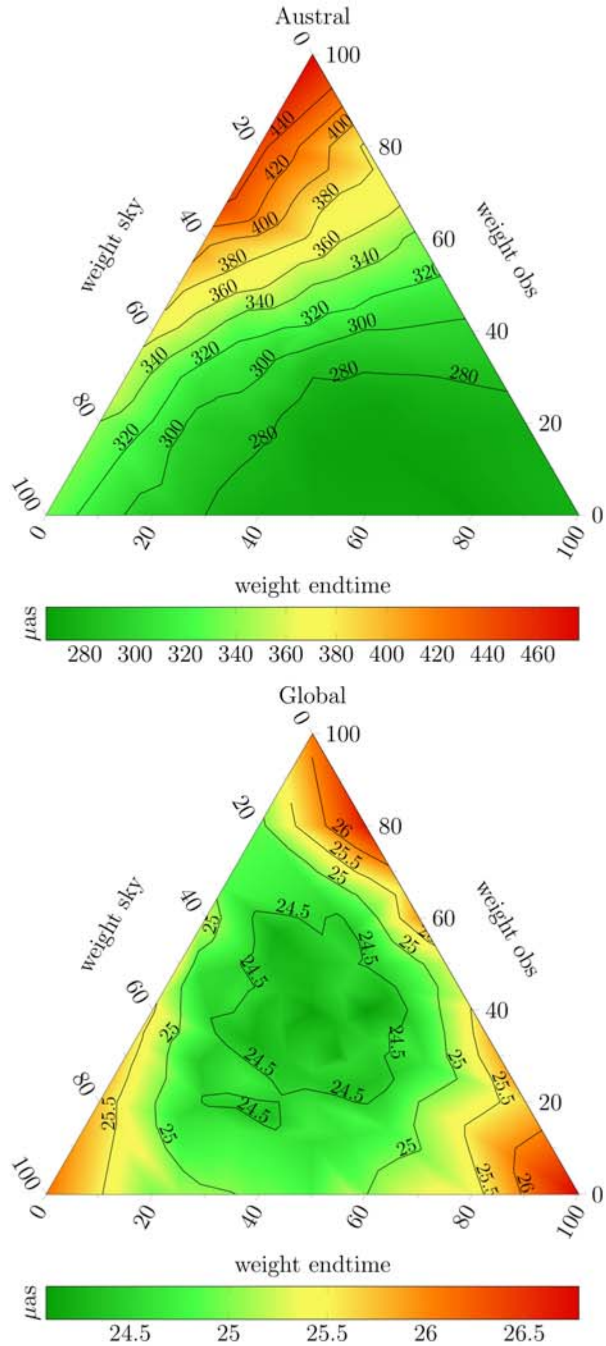

Fig. 6: Mean result for polar motion in x-direction after simulating each schedule 50 times. Note that the best results do not correspond with the areas of the highest number of observations in Figure 5. Different weight factors for the Austral network and a global network show best results.

ferred locations. To create a good schedule it is critical to use an appropriate set of weight factors in VieVS. The most suitable set of weight factors depends on the station network and the session task, which means that for each network different parameters should be used. With the new changes in VieVS it is now easier to try different parameters and get a good result.

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